forest management note

Note No. 19 Northern Forest Research Centre Edmonton, Alberta

TABLES FOR DETERMINING SPRING DROUGHT CODE STARTING VALUES IN WEST-CENTRAL AND NORTHERN CANADA

Fire danger conditions in the forested regions of the prairie provinces and the Northwest Territories are monitored by a network of about 350 fire weather stations. Meteorological drought or cumulative dryness greatly aggravates the problems experienced in forest fire containment and extinguishment; fires burn deeper and with greater vigor simply because more fuel is available for combustion, fire lines are frequently challenged, and mop-up is often an extended, expensive operation. Troublesome situations commonly occur where heavy duff fuels have undergone a prolonged period of drying.

The effect of long-term drying on the moisture content of deep, compact, organic matter is measured by the Drought Code (DC) in the Canadian Forest Fire Danger Rating System. Winter precipitation is generally sufficient to start the DC in the spring at a standard value of 15 on the third day after snowmelt is complete. In parts of the region, overwinter precipitation sometimes falls short of the amount required for saturation of the DC fuel layer. In these instances, the DC starting value must be adjusted upward prior to starting spring calculations in order to account for this moisture deficiency. Above-normal snowfall negates any deficiency. In addition, a heavy snowpack tends to shorten the transition period from a "cured" state (exposed deciduous leaf litter and dead herbaceous material from the previous year) to a "green-up" state (leafing-out of hardwood trees and understory vegetation).

The procedure for making overwinter adjustments of spring DC starting values at network fire weather stations is described in Appendix 1 of Turner and Lawson (1978). The degree of adjustment depends on the DC value reached on the last day of index calculations the previous autumn, total winter precipitation (mm water equivalent), seasonal climatic conditions, and ecosystem characteristics. Fractional values must be selected for the carry-over fraction of the previous fall's moisture and the effectiveness of winter precipitation in recharging depleted duff/soil moisture reserves in the spring. The carry-over fraction of fall moisture is the percentage of the fall DC that is carried over to the spring. Three values have been recommended: 1.00, 0.75, and 0.50. A value of 1.00 indicates that there was no increase in the DC from fall to spring due to evapotranspiration in late fall, whereas the use of 0.75 and 0.50 assumes a drying trend. Determining the portion of total winter precipitation that actually percolates into the ground in the spring is a complex matter. In the absence of any reliable scheme, three values for the precipitation effectiveness fraction have been suggested: 0.50, 0.75, and 0.90.

The purpose of this note is to present tabular summaries of the equations determined by Turner and Lawson (1978) for situations likely to be encountered in the prairie provinces and the Northwest Territories as well as other regions (Tables 1 to 6). A series of tables for determining spring DC starting values is used here rather than the graph method described by Turner and Lawson (1978). Readers are encouraged to review Appendix 1 of Turner and Lawson (1978) and a companion note on the subject of overwinter adjustment of spring starting values of the DC (Alexander 1982).

Interpolation between rows and columns will be necessary in determining spring DC starting values. For example (using Table 1), if the fall DC is 533 and overwinter precipitation totals 172 mm, then the spring DC is 150. The tables can be used for overwinter monitoring of the DC; specifically, potential spring DC starting values can be compared against cumulative overwinter precipitation (i.e., precipitation between the fall closing date and spring starting date).

A major requirement in the adjustment of spring DC starting values is a set of overwinter precipitation data. This information is partially provided by the year-round meteorological observing stations administered by the Atmospheric Environment Service (AES). Current listings of stations by area are available (Atmospheric Environment Service 1981). Some regions have snowpack data available from hydrological surveys[1] (transect locations are listed in the AES annual winter publication, *Snow Cover Data*) and other sources (e.g., Alberta's Sacramento Precipitation Storage Gauge Network) to supplement the AES network of weather stations.

Turner and Lawson (1978) presented an equation method for manually determining spring DC starting values with a nonprogrammable desk-top pocket calculator. For users having access to a Texas Instruments Model 59 (TI-59) programmable hand-held calculator[2], a more efficient program has been developed (Appendix 1). A copy of the program can be obtained by sending a single blank TI-59 magnetic card to the author. A listing of program contents is available on request.

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Table 1. Overwinter adjustment of spring Drought Code starting value table for a carry-over fraction of fall moisture of 1.00 and a precipitation effectiveness fraction of 0.50*

Fall Drought Code	Overwinter precipitation (mm water equivalent)																	
	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340
	Spring Drought Code																	
0	15																	
20	20	15																
40	40	19	15															
60	60	38	17	15														
80	80	57	35	15														
100	100	75	52	30	15													
120	120	94	70	47	26	15												
140	140	113	88	64	41	20	15											
160	160	132	105	80	57	35	15											
180	180	150	123	97	72	49	28	15										
200	200	169	140	113	87	64	41	20	15									
220	220	187	157	129	103	78	55	33	15									
240	240	206	174	145	117	92	68	45	24	15								
260	260	224	191	160	132	105	81	57	35	15								
280	280	242	208	176	146	119	93	69	46	25	15							
300	300	260	224	191	161	132	106	81	57	35	15							
320	320	278	241	206	175	145	118	92	68	45	24	15						
340	340	296	257	221	188	158	130	103	79	55	33	15						
360	360	314	273	236	202	171	141	114	89	65	43	21	15					
380	380	332	289	251	215	183	153	125	99	75	51	30	15					
400	400	350	305	265	228	195	164	136	109	84	60	38	17	15				
420	420	367	321	279	241	207	175	146	118	93	69	46	24	15				
440	440	385	336	293	254	218	186	156	128	101	77	54	32	15				
460	460	402	352	307	267	230	196	165	137	110	85	61	39	18	15			
480	480	419	367	320	279	241	207	175	145	118	92	68	46	24	15			
500	500	437	382	334	291	252	217	184	154	126	100	75	52	30	15			
520	520	454	397	347	302	263	226	193	162	134	107	82	59	37	15			
540	540	470	411	360	314	273	236	202	170	141	114	89	65	42	21	15		
560	560	487	426	372	325	283	245	210	178	149	121	95	71	48	26	15		
580	580	504	440	385	336	293	254	218	186	156	128	101	77	54	32	15		
600	600	520	454	397	347	303	263	226	193	162	134	107	82	59	37	16	15	
620	620	537	468	409	357	312	271	234	200	169	140	113	88	64	41	20	15	
640	640	553	481	420	368	321	279	242	207	175	146	118	93	69	46	24	15	
660	660	569	494	432	378	330	287	249	214	181	152	124	98	73	50	29	15	
680	680	585	507	443	387	339	295	256	220	187	157	129	103	78	55	33	15	
700	700	600	520	454	397	347	303	263	226	193	162	134	107	82	59	37	16	15
720	720	616	533	465	406	355	310	269	232	199	168	139	112	86	62	40	19	15
740	740	631	545	475	415	363	317	276	238	204	172	143	116	91	67	44	23	15
760	760	646	558	485	424	371	324	282	244	209	177	148	120	94	70	47	26	15
780	780	661	570	495	432	378	330	288	249	214	182	152	124	98	74	51	29	15
800	800	676	581	505	441	385	337	294	254	219	186	156	128	102	77	54	32	15

* For use (a) when daily calculations of the DC we[illegible]inued until continuous snow cover, ground freeze-up, or November 1 (whichever came first); and (b) in chinook-pro[illegible]as subject to early and deep ground frost, well-drained sites favoring rapid percolation (e.g., sandy soils), or top[illegible]voring rapid runoff prior to melting of ground frost in the spring.

[1] The water equivalent of the maximum recorded snowpack depth can be considered an approximate indication of total overwinter precipitation.

[2] The exclusion of certain manufactured products does not imply rejection nor does the mention of other products imply endorsement by the Canadian Forestry Service.

Table 2. Overwinter adjustment of spring Drought Code starting value table for a carry-over fraction of fall moisture of 1.00 and a precipitation effectiveness fraction of 0.75*

Fall Drought Code	Overwinter precipitation (mm water equivalent)												
	0	20	40	60	80	100	120	140	160	180	200	220	240
	Spring Drought Code												
0	15												
20	20	15											
40	40	15											
60	60	27	15										
80	80	45	15										
100	100	64	31	15									
120	120	82	47	15	15								
140	140	100	64	31	15								
160	160	118	80	46	15								
180	180	136	97	61	28	15							
200	200	154	113	75	41	15							
220	220	172	129	90	55	22	15						
240	240	190	145	104	68	34	15						
260	260	207	160	118	81	46	15						
280	280	225	176	132	93	58	25	15					
300	300	242	191	146	106	69	35	15					
320	320	259	206	160	118	80	45	15					
340	340	276	221	173	130	91	55	23					
360	360	293	236	186	141	101	65	32	15				
380	380	310	251	199	153	112	75	40	15				
400	400	327	265	211	164	122	84	49	17	15			
420	420	343	279	224	175	132	93	57	24	15			
440	440	360	293	236	186	141	101	65	32	15			
460	460	376	307	248	196	151	110	73	39	15			
480	480	392	320	259	207	160	118	80	46	15			
500	500	408	334	271	217	169	126	87	52	20	15		
520	520	424	347	282	226	177	134	95	59	26	15		
540	540	440	360	293	236	186	141	101	65	32	15		
560	560	455	372	304	245	194	149	108	71	37	15		
580	580	471	385	314	254	202	156	114	77	42	15		
600	600	486	397	324	263	209	162	120	82	48	16	15	
620	620	501	409	334	271	217	169	126	88	52	20	15	
640	640	515	420	344	279	224	175	132	93	57	25	15	
660	660	530	432	353	287	231	182	138	98	62	29	15	
680	680	544	443	362	295	238	187	143	103	66	33	15	
700	700	558	454	371	303	244	193	148	107	70	37	15	
720	720	572	465	380	310	250	199	153	112	74	40	15	
740	740	586	475	388	317	257	204	158	116	78	44	15	
760	760	599	485	396	324	262	209	162	120	82	47	15	
780	780	613	495	404	330	268	214	167	124	86	51	19	15
800	800	626	505	412	337	274	219	171	128	89	54	21	15

* For use (a) when daily calculations of the DC were continued until continuous snow cover, ground freeze-up, or November 1 (whichever came first); and (b) in areas where deep ground frost does not occur except late into the fall or moderately drained sites where a major portion of the melting snowpack would infiltrate the duff and soil layers regardless of when spring thaw occurs.

Table 3. Overwinter adjustment of spring Drought Code starting value table for a carry-over fraction of fall moisture of 1.00 and a precipitation effectiveness fraction of 0.90[1],*

Fall Drought Code	Overwinter precipitation (mm water equivalent)										
	0	20	40	60	80	100	120	140	160	180	200
	Spring Drought Code										
0	15										
20	20	15									
40	40	15									
60	60	21	15								
80	80	39	15								
100	100	57	18	15							
120	120	75	34	15							
140	140	93	50	15							
160	160	110	66	26	15						
180	180	128	82	41	15						
200	200	145	97	55	16	15					
220	220	163	113	68	28	15					
240	240	180	128	82	41	15					
260	260	197	143	95	53	15					
280	280	214	158	108	64	25	15				
300	300	231	173	121	76	35	15				
320	320	248	187	134	87	45	15				
340	340	265	201	147	98	55	17	15			
360	360	281	215	159	109	65	25	15			
380	380	297	229	171	120	75	34	15			
400	400	314	243	182	130	84	42	15			
420	420	330	256	194	140	93	50	15			
440	440	346	269	205	150	101	58	19	15		
460	460	361	282	216	159	110	66	26	15		
480	480	377	295	227	169	118	73	33	15		
500	500	392	307	237	178	126	80	39	15		
520	520	407	320	248	187	134	87	45	15		
540	540	422	332	258	195	141	94	51	15		
560	560	437	343	267	204	149	100	57	18	15	
580	580	452	355	277	212	156	106	63	23	15	
600	600	466	366	286	219	162	112	68	28	15	
620	620	480	377	295	227	169	118	73	33	15	
640	640	494	388	304	234	175	124	78	37	15	
660	660	508	398	312	242	181	129	83	42	15	
680	680	522	409	321	249	187	134	88	46	15	
700	700	535	419	329	255	193	139	92	50	15	
720	720	548	428	336	262	199	144	96	54	15	
740	740	561	438	344	268	204	149	101	57	18	15
760	760	574	447	351	274	209	153	104	61	22	15
780	780	586	456	358	280	214	158	108	64	25	15
800	800	599	465	365	285	219	162	112	68	28	15

[1] This value is probably an upper limit of possible precipitation effectiveness.

* For use (a) when daily calculations of the DC were continued until continuous snow cover, ground freeze-up, or November 1 (whichever came first); and (b) in areas characterized by poorly drained, boggy sites with deep organic layers.

Table 4. Overwinter adjustment of spring Drought Code starting value table for a carry-over fraction of fall moisture of 0.75 and a precipitation effectiveness fraction of 0.50*

Fall Drought Code	Overwinter precipitation (mm water equivalent)																		
	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360
	Spring Drought Code																		
0	115	90	66	43	22	15													
20	135	108	83	60	37	16	15												
40	155	127	101	76	53	31	15												
60	175	146	118	93	68	46	24	15											
80	195	164	135	109	84	60	38	17	15										
100	215	183	153	125	99	74	51	29	15										
120	235	201	170	141	114	88	64	42	21	15									
140	255	219	187	156	128	102	77	54	32	15									
160	275	238	203	172	143	116	90	66	43	22	15								
180	295	256	220	187	157	129	103	78	55	33	15								
200	315	274	237	202	171	142	115	89	65	43	22	15							
220	335	292	253	217	185	155	127	101	76	53	31	15							
240	355	310	269	232	199	167	139	112	86	63	40	19	15						
260	375	328	285	247	212	180	150	122	96	72	49	28	15						
280	395	345	301	261	225	192	161	133	106	81	58	36	15						
300	415	363	317	276	238	204	172	143	116	90	66	44	22	15					
320	435	380	332	290	251	216	183	153	125	99	75	52	30	15					
340	455	398	348	303	263	227	194	163	134	108	83	59	37	16	15				
360	475	415	363	317	276	238	204	172	143	116	90	66	44	22	15				
380	495	432	378	330	288	249	214	182	152	124	98	74	51	29	15				
400	515	449	393	343	299	260	224	191	160	132	105	80	57	35	15				
420	535	466	408	356	311	270	233	199	168	139	112	87	63	41	20	15			
440	555	483	422	369	322	280	243	208	176	147	119	93	69	47	25	15			
460	575	500	436	381	333	290	252	216	184	154	126	100	75	52	30	15			
480	595	516	450	394	344	300	260	224	191	161	132	106	81	57	35	15			
500	615	532	464	406	355	310	269	232	198	167	138	111	86	63	40	19	15		
520	635	549	478	417	365	319	277	240	205	174	144	117	91	67	45	23	15		
540	655	565	491	429	375	328	285	247	212	180	150	122	97	72	49	28	15		
560	675	581	504	440	385	336	293	254	219	186	156	128	101	77	54	32	15		
580	695	596	517	451	395	345	301	261	225	192	161	133	106	81	58	36	15		
600	715	612	530	462	404	353	308	268	231	197	166	138	111	85	62	39	18	15	
620	735	627	542	472	413	361	315	274	237	203	171	142	115	90	66	43	22	15	
640	755	642	555	483	422	369	322	280	242	208	176	147	119	93	69	47	25	15	
660	775	657	567	493	430	376	329	286	248	213	181	151	123	97	73	50	28	15	
680	795	672	578	502	439	384	335	292	253	218	185	155	127	101	76	53	31	15	
700	815	687	590	512	447	391	341	298	258	222	189	159	131	104	79	56	34	15	
720	835	701	601	521	455	397	347	303	263	227	193	163	134	108	83	59	37	16	15
740	855	715	612	530	462	404	353	308	268	231	197	166	138	111	86	62	39	18	15
760	875	729	623	539	469	410	359	313	272	235	201	170	141	114	88	64	42	21	15
780	895	743	633	547	477	416	364	318	277	239	205	173	144	117	91	67	44	23	15
800	915	757	644	556	483	422	369	323	281	243	208	176	147	119	94	70	47	25	15

* For use (a) when daily calculations of the DC were curtailed too early (i.e., before continuous snow cover, ground freeze-up, or November 1); and (b) in chinook-prone areas, areas subject to early and deep ground frost, well-drained sites favoring rapid percolation (e.g., sandy soils), or topography favoring rapid runoff prior to melting of ground frost in the spring.

Table 5. Overwinter adjustment of spring Drought Code starting value table for a carry-over fraction of fall moisture of 0.75 and a precipitation effectiveness fraction of 0.75*

Fall Drought Code	Overwinter precipitation (mm water equivalent)												
	0	20	40	60	80	100	120	140	160	180	200	220	240
	Spring Drought Code												
0	115	78	43	15									
20	135	96	60	27	15								
40	155	114	76	42	15								
60	175	132	93	57	24	15							
80	195	150	109	72	38	15							
100	215	167	125	86	51	19	15						
120	235	185	141	101	64	31	15						
140	255	203	157	115	77	43	15						
160	275	220	172	129	90	55	22	15					
180	295	238	187	143	103	66	33	15					
200	315	255	203	156	115	77	43	15					
220	335	272	218	170	127	88	53	21	15				
240	355	289	232	183	139	99	63	30	15				
260	375	306	247	196	150	109	72	38	15				
280	395	323	261	208	161	120	82	47	15				
300	415	339	276	221	173	129	91	55	23	15			
320	435	356	290	233	183	139	99	63	30	15			
340	455	372	303	245	194	149	108	71	37	15			
360	475	388	317	257	204	158	116	78	44	15			
380	495	404	330	268	214	167	124	86	51	18	15		
400	515	420	344	279	224	175	132	93	57	24	15		
420	535	436	356	290	233	184	139	100	63	30	15		
440	555	451	369	301	243	192	147	106	69	36	15		
460	575	467	382	311	252	200	154	113	75	41	15		
480	595	482	394	322	261	208	161	119	81	46	15		
500	615	497	406	332	269	215	167	125	86	51	19	15	
520	635	512	418	341	277	222	174	131	92	56	23	15	
540	655	526	429	351	285	229	180	136	97	61	28	15	
560	675	541	440	360	293	236	186	142	102	65	32	15	
580	695	555	451	369	301	243	192	147	106	69	36	15	
600	715	569	462	378	308	249	197	152	111	73	39	15	
620	735	583	472	386	315	255	203	156	115	77	43	15	
640	755	596	483	394	322	261	208	161	119	81	47	15	
660	775	610	493	402	329	267	213	166	123	85	50	18	15
680	795	623	502	410	335	272	218	170	127	88	53	21	15
700	815	635	512	418	342	278	222	174	131	92	56	23	15
720	835	648	521	425	348	283	227	178	134	95	59	26	15
740	855	661	530	432	353	288	231	182	138	98	62	29	15
760	875	673	539	439	359	292	235	185	141	101	65	31	15
780	895	685	548	446	364	297	239	189	144	104	67	34	15
800	915	696	556	452	370	301	243	192	147	106	70	36	15

* For use (a) when daily calculations of the DC were curtailed too early (i.e., before continuous snow cover, ground freeze-up, or November 1) or if the area has been subjected to occasional winter chinook conditions that have favored moisture depletion; and (b) in areas where deep ground frost does not occur except late into the fall or moderately drained sites where a major portion of the melting snowpack would infiltrate the duff and soil layers regardless of when spring thaw occurs.

Table 6. Overwinter adjustment of spring Drought Code starting value table for a carry-over fraction of fall moisture of 0.75 and a precipitation effectiveness fraction of 0.90[1],*

Fall Drought Code	Overwinter precipitation (mm water equivalent)										
	0	20	40	60	80	100	120	140	160	180	200
	Spring Drought Code										
0	115	70	30	15							
20	135	88	46	15							
40	155	106	62	23	15						
60	175	124	78	37	15						
80	195	141	94	51	15						
100	215	159	109	65	25	15					
120	235	176	124	79	38	15					
140	255	193	139	92	50	15					
160	275	210	154	105	62	22	15				
180	295	227	169	118	73	33	15				
200	315	244	183	131	85	43	15				
240	355	277	212	156	107	63	23	15			
260	375	293	226	168	117	72	32	15			
280	395	310	239	180	128	81	40	15			
300	415	326	253	191	138	91	48	15			
320	435	342	266	202	148	99	56	17	15		
340	455	357	279	213	157	108	64	24	15		
360	475	373	292	224	167	116	71	31	15		
380	495	388	304	235	176	124	78	37	15		
400	515	404	317	245	185	132	85	44	15		
420	535	419	329	255	193	139	92	50	15		
440	555	434	340	265	202	147	99	56	17	15	
460	575	448	352	275	210	154	105	61	22	15	
480	595	463	363	284	218	161	111	67	27	15	
500	615	477	374	293	225	167	117	72	32	15	
520	635	491	385	302	233	174	122	77	36	15	
540	655	505	396	310	240	180	128	82	41	15	
560	675	518	406	319	247	186	133	87	45	15	
580	695	532	416	327	254	192	138	91	49	15	
600	715	545	426	335	260	197	143	95	53	15	
620	735	558	436	342	266	203	148	100	56	18	15
640	755	571	445	350	273	208	152	104	60	21	15
660	775	583	454	357	278	213	157	107	64	24	15
680	795	596	463	364	284	218	161	111	67	27	15
700	815	608	472	370	290	222	165	115	70	30	15
720	835	619	480	377	295	227	169	118	73	33	15
740	855	631	488	383	300	231	172	121	76	35	15
760	875	642	496	389	305	235	176	124	79	38	15
780	895	653	504	395	310	239	179	127	81	40	15
800	915	664	511	400	314	243	183	130	84	42	15

[1] This value is probably an upper limit of possible precipitation effectiveness.

* For use (a) when daily calculations of the DC were curtailed too early (i.e., before continuous snow cover, ground freeze-up, or November 1), and (b) in areas characterized by poorly drained, boggy sites with deep organic layers.

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Dr. C.Y. Lee, former Systems Analyst at the Northern Forest Research Centre, completed the TI-59 program for calculating spring DC starting values.

Appendix 1. Operating instructions for calculating spring Drought Code starting values with the Texas Instruments Model 59 hand-held calculator

Step	Procedure	Enter	Press	Display
1	Turn calculator on			0
2	Clear memory		2nd CP	0.
3	Insert Side 1 of program card			1.
4	Initiate program		A	1.00
5	Enter fall Drought Code	nnn[1]	R/S	nnn
6	Enter carry-over fraction of fall moisture	n.nn	R/S	n.nn
7	Enter precipitation effectiveness fraction	n.nn	R/S	n.nn
8	Enter overwinter precipitation (mm water equivalent)	nnn	R/S	Flickering C
9	Spring Drought Code displayed[2]			nnn[3]
	To complete another program computation, return to Step 4			

[1] The label n refers to any user-defined input number.

[2] The input and output data are contained in the following storage registers and can be recalled simply by pressing RCL (for registers 01 and 04 to 07) or 2nd Fix 2 (for registers 02 and 03) followed by the appropriate two-digit register number:

Register number	Symbol	Contents
00	.	Not used
01	DC_F	Fall Drought Code
02	a	Carry-over fraction of fall moisture
03	b	Precipitation effectiveness fraction
04	P	Overwinter precipitation (mm water equivalent)
05	SMI_F	DC_F expressed in units of Stored Moisture Index
06	SMI_S	DC_S expressed in units of Stored Moisture Index
07	DC_S	Spring Drought Code

[3] Any value calculated to be less than 15 is set equal to 15.

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